USDA United States Department of Agriculture
Forest Service

PNW Pacific Northwest Research Station

Science FINDINGS

INSIDE

issue one hundred eighty four / april 2016

"Science affects the way we think together."
Lewis Thomas

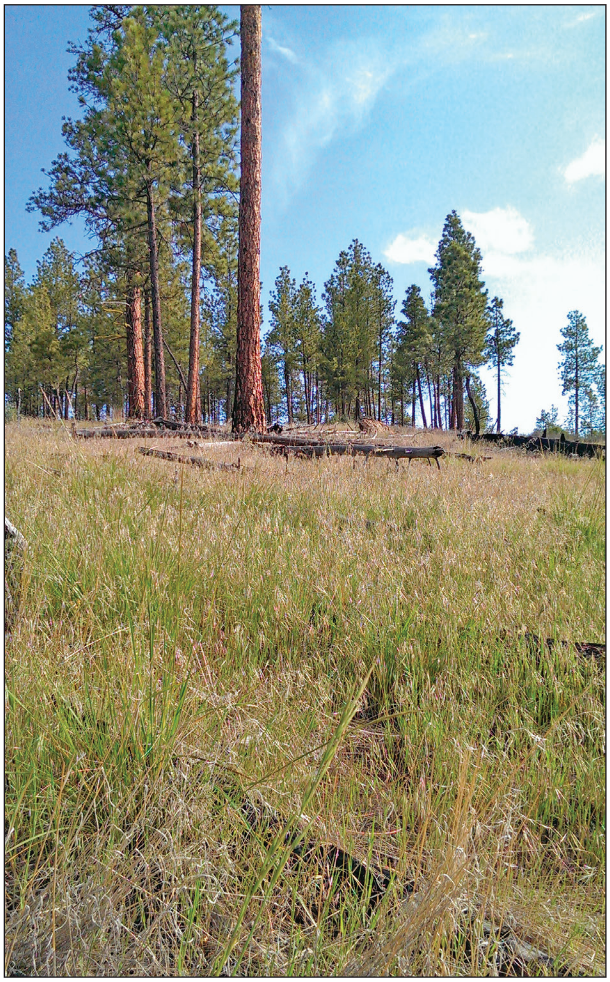
Predicting the Unpredictable: Potential Climate Change Impacts on Vegetation in the Pacific Northwest

"It is far better to foresee even without certainty than not to foresee at all."
—Henri Poincaré

Foresters are no longer asking if climate change is occurring; the question now is how to manage forests in the face of it. Warming temperatures, changes in temperature variability, precipitation patterns, and climate-related disturbances are now linked to observed ecosystem changes in the Pacific Northwest, and these changes are anticipated to continue in the future.

In 2010, the Forest Service began requiring that all national forests and grasslands address climate change in their land management plans. Although climate change research has been ongoing for decades, applying it to management is still relatively new for many land managers.

"There has been a lot of confusion among managers who are confronting a host of issues for the first time, particularly around the limitations of modeling, how to use model output, and the lack of certainty about the future," says Becky Kerns, a research ecologist with the Pacific Northwest (PNW) Research Station.



Becky Kerns

Future climate changes will likely lead to new vegetation communities. Nonnative cheatgrass has invaded a site in the Malheur National Forest which was thinned and then burned at 5-year intervals.

Studies related to climate change and its potential effects on ecosystems are proliferating at a rapid clip, making it difficult

IN SUMMARY

Earth's climate is changing, as evidenced by warming temperatures, increased temperature variability, fluctuating precipitation patterns, and climate-related environmental disturbances. And with considerable uncertainty about the future, Forest Service land managers are now considering climate change adaptation in their planning efforts. They want practical approaches to managing forests and rangelands that will sustain key ecosystem functions, services, and critical habitats in the face of climate change. Climate change studies are proliferating, and locating pertinent information, as it applies to a particular Northwest landscape, can be a daunting task.

Two Pacific Northwest Research Station scientists and their collaborators reviewed and synthesized extensive scientific knowledge and summarized model projections that describe vegetation vulnerability to climate-related environmental changes in the Pacific Northwest. They evaluated climate change issues for the region's five major biome types: (1) subalpine forests and alpine meadows, (2) maritime coniferous forests, (3) dry coniferous forests, (4) savannas and woodlands, and (5) interior shrub-steppe. A general technical report titled Climate Change Effects on Vegetation in the Pacific Northwest *provides a valuable snapshot of current information on a wide variety of climate change issues that managers may encounter during planning processes and in interactions with stakeholders.*

to keep up with the latest findings. It's especially challenging to determine which findings are applicable to a given locale and how much weight to give to certain modeled scenarios. Consequently, land managers are looking for synthesized scientific information about the potential effects of climate change.

With support from the Bureau of Land Management, Kerns and Dave Peterson, a research forester with the PNW Research Station, collaborated with other scientists to conduct a literature review and develop a new resource that can be used in climate change adaptation planning. This work was published in September 2014 in a report titled *Climate Change Effects on Vegetation in the Pacific Northwest: A Review and Synthesis of the Scientific Literature*.

The report summarizes large volumes of scientific knowledge on diverse topics across the fields of climatology, hydrology, plant physiology and ecology, disturbance ecology, and modeling, and identifies knowledge gaps related to vegetation vulnerability to climatic and other environmental changes in the Pacific Northwest. It examines the risks related to exposure, sensitivity, and species adaptability for the five major biome types in the region: (1) subalpine forests and alpine meadows, (2) maritime, coniferous forests, (3) dry coniferous forests, (4) juniper savannas and woodlands, and (5) interior shrub-steppe.

KEY FINDINGS

- Plant species differ in their tolerance of, and ability to adapt to, a changing climate, and future climatic changes will produce new vegetation communities.
- Disturbances such as drought, fire, and insect outbreaks will be the likely catalysts for vegetation changes.
- Climatic influences vary greatly among ecosystem types, so ecosystems are likely to respond differently to future climatic changes. Multiple lines of evidence agree that alpine and subalpine forests and habitats are most at risk.
- Climate change and increasing CO_2 concentrations will probably increase some exotic plant invasions.
- The science of ecosystem modeling is not yet mature enough to suggest which modeling approach is best for projecting vegetation responses to climate change. Examination of multiple models can help address this issue.
- Because future conditions will strongly differ from those of the past, the "historic range of variability" concept has a limited utility as the basis for planning. Applying our understanding of processes and interactions to current biophysical, social, and economic environments may be the best way to manage for uncertainty or change.

SO MANY MODELS

The synthesis highlights the importance of carefully choosing which models to use and how to use them.

"The problem is that models have to simplify the world," says Peterson. "But they can be useful for giving us ideas about what we should be looking for and where we should be looking for it."

Models that look at potential impacts on a particular resource, such as snowmelt, hydrology, or vegetation, can provide valuable perspectives, but Peterson warns land managers to proceed with caution.

C. Alina Casler

Alpine forests are projected to experience the most change in the future, as snowpacks diminish and fire becomes more frequent. Above, the Lake Chelan-Sawtooth Wilderness, Washington.

Purpose of PNW Science Findings

To provide scientific information to people who make and influence decisions about managing land.

PNW Science Findings is published monthly by:

Pacific Northwest Research Station
USDA Forest Service
P.O. Box 3890
Portland, Oregon 97208

Send new subscriptions and change of address information to:

pnw_pnwpubs@fs.fed.us

Rhonda Mazza, editor; rmazza@fs.fed.us

Cheryl Jennings, layout; cjennings@fs.fed.us

Science Findings is online at: http://www.fs.fed.us/pnw/publications/scifi.shtml

To receive this publication electronically, change your delivery preference here:

http://www.fs.fed.us/pnw/publications/subscription.shtml

USDA United States Department of Agriculture

Forest Service

"A species distribution model might say that a species is likely to move 100 miles north in the future," he says. "But the model can't tell you how it would get there, or how well it will compete with the vegetation that's already there."

Although longer term growing conditions might be suitable for a particular species in a new location, the migratory path to that location may not be straightforward. For example, higher temperatures and less precipitation could make it difficult for seeds to regenerate, or a disturbance might make it difficult for seeds to land in suitable habitat.

"You could be looking at a two- or three-hundred-year window—it has a pretty good chance of happening, but it could be a pretty messy couple of centuries," says Peterson.

The study team looked at a wide range of vegetation models, such as gap, species distribution, and process models. It reviewed the major classes of vegetation models; described their basic function, strengths, and weaknesses; discussed the contribution each could make toward understanding and projecting vegetation responses to future climatic changes; and made recommendations about how to use the output.

"Model output can be used as a basis for discussion among resource teams that are considering management and climate change adaptation actions," says Kerns, "but we suggest that folks also factor in long-term data from the paleoecological record, observational and experimental studies, and local knowledge, to assess potential and plausible climate change effects. We want people to step away from thinking about models as a definite forecast, and instead use them as a 'what if' scenario—more of a thought process than a prediction."

The research team synthesized multiple model projections for future vegetation responses to disturbances, changing environmental controls, and elevated atmospheric carbon dioxide for key species in the five major biomes of the Pacific Northwest. The models agree that alpine and subalpine forests and habitats are most at risk, primarily because of warming temperatures, earlier snowmelt, and longer growing seasons.

Models for dry coniferous forests, savannas and woodlands, and shrub-steppe are less consistent in their predictions. "The models generally predict warmer temperatures, but they tend to be a little inconsistent about precipitation," says Peterson. "It's harder to make confident decisions based on the projections from these models for some of those biomes."

DISTURBANCE AND INVASIVE SPECIES

Because weather patterns vary from one year to the next, trees and other plants have developed survival mechanisms that give them some ability to adapt as conditions change, so even when a tree is severely stressed, it can potentially survive for decades under less-than-optimal conditions. Species can adapt to a new climate either through internal changes in existing plants or through generational evolution, which makes species migration a very slow process.

Kerns and Peterson suggest that it will probably take a major disturbance, such as an insect infestation, wildfire, logging, or a long-term drought to catalyze major changes in vegeta-

Becky Kerns

*North Africa grass (*Ventenata dubia*) has invaded the site above, creating a continuous fuel cover that could facilitate the spread of wildfire.*

Becky Kerns

The native vegetation community is relatively intact at this site in the Blue Mountains. The native ground cover provides less fuel than invasive annual grasses.

tion on a particular landscape. Of course, the more stressed a forest becomes, the more vulnerable it is to any major disturbance, so taking management actions that lead to resiliency in the face of disturbance is one way of hedging bets against the effects of climate change.

Some plant species will probably do better under climate change, Kerns suggests, and these may not be the species that have historically been considered desirable in the Pacific Northwest.

"A lot of the invasive plants we have—especially in the interior forests east of the Cascade crest—tend to be fairly well adapted to hot and dry climates," she says. "So as the Northwest gets warmer, that potentially means opening up more habitat for those species to do well."

Many invasive species are opportunistic and are able to quickly colonize a burned or logged area, landslide, or other opening created by a disturbance. "They might exist in a relatively low population numbers and then increase exponentially after a certain amount of time," says Kerns. "So people might think, 'Okay, we have a little time to think.' But, really, the best way to combat invasive species is early detection and rapid response."

She concludes that land managers may need to choose their battles. "Some species might become too costly to mitigate, and so we might live with it," she says.

Realistically, the complete eradication of an exotic species may be too costly or even impossible. An option might be to try to keep it from spreading while encouraging native species that may compete with it in a changing climate. "Even if that species was not historically that common, we still might have a well-functioning ecosystem," says Kerns.

Kerns and Peterson suggest framing goals in terms of a range of future possibilities. "Managing to maintain options makes the most sense, keeping historical conditions in mind, but also allowing for the possible emergence of altered vegetation communities and ecosystem services under a new climate," says Peterson.

PLANNING WITH UNCERTAINTY IN MIND

If anything is now clear about climate change, it's that the future is uncertain.

Peterson suggests that certain "no-regrets" management policies can hedge bets for the future under potential climate change scenarios while also reflecting healthy forest practices. Fuel reduction treatments designed to reduce immediate fire hazards, such as thinning and prescribed burns, also will benefit future forests, for instance.

Becky Kerns

Drought-stressed forests are more susceptible to insect infestations and wildfire—catalysts for major change in vegetation on a particular landscape.

"Hotter, drier summers; longer snow-free periods; more intense droughts—all tend to increase the frequency, size, and severity of wildfires," says Peterson. "If you address that problem, even if for some reason you're totally wrong about climate change, you're still putting your money into something useful. Forest restoration is a 'no-regrets' policy, because it is helping us now and it will help us in the future."

The same approach might be used for managing the spread of invasive species or maintaining biodiversity. "It is something we want to do now, anyway. The problem might get worse under climate change or it might become more urgent, but it's an existing problem, so we address it in the best way we can," he says.

Other questions, like helping species migrate, are more specific to climate change and may be subject to more debate, because they don't usually address current problems. But factoring climate change into discussions about forest regeneration after fire or logging could be useful, Peterson points out.

"We're having active conversations like, 'Should we plant from the same seed zones we always have, or should we draw on seeds from a warmer area?' Because trees that come from those seeds might be better adapted to the future climate," he says.

A STARTING PLACE FOR MANAGEMENT PLANNING

The synthesis is proving quite useful on several fronts. Kerns and her collaborators used the publication to inform their work on climate change vulnerability assessment and adaptation planning for the Blue Mountains Region, which includes the Malheur, Umatilla, and Wallowa-Whitman National Forests. They are currently doing the same for the south-central Oregon region, which includes the Ochoco, Deschutes, and Fremont-Winema National Forests; the Crooked River National Grassland; and Crater Lake National Park.

"We basically go back to the report to summarize some fundamental information, and then look at the latest findings to supplement it," says Kerns.

Louisa Evers, research liaison and climate change coordinator for the Oregon/Washington state office of the Bureau of Land Management, used the report as one reference to support the climate change section of the Western Oregon Resource Management Plan revision. Like Kerns, she used it as a solid starting place and supplemented it with recent peer-reviewed findings for the appropriate area. The latest findings in the report are dated 2012.

"A lot of good information has come out since the report was published, but the basics are still sound," says Evers. "We just keep getting more detail and more refinements to it coming through the peer-reviewed literature. So far, there hasn't been anything dramatically new that has made the report out of date."

Matthew Reilly, an Oregon State University researcher on regional forest dynamics, is working with Tom Spies, a research forester with the PNW Research Station, to review findings on climate change for an upcoming synthesis of science pertaining to the Northwest Forest Plan. He says the report gives him a good starting place for his research.

"It can take an awfully long time for me to have to dive into Google™ to search for information related to climate change," says Reilly. "This is a good synthesis of what we know, and a good representation of how much confidence we have in what we know."

To help land managers in the field, the Forest Service's Pacific Northwest Region is using the report to inform the development of a series of climate change fact sheets, says Becky Gravenmier, science and climate change coordinator with the PNW Region. The facts sheets are available from the Climate Change Resource Center (www.fs.usda.gov/ccrc). Land managers are able to use them as a quick reference for the current state of scientific knowledge in a particular area of concern.

"If you can look into the seeds of time, and say which grain will grow and which will not, speak then unto me."
—William Shakespeare, Macbeth

LAND MANAGEMENT IMPLICATIONS

- *Climate Change Effects on Vegetation in the Pacific Northwest* can be used when developing land management plans, climate change vulnerability assessments, project-level National Environmental Policy Act assessments, and more.
- Biome-oriented information gives land managers specific information about their particular regions and suggests which climate-related changes are most likely to affect individual units and management activities.
- Reviewing potential climate change impacts reveals potential "no-regrets" management strategies that can contribute to climate change adaptation and also meet present-day needs.
- Vegetation models are useful for pointing to the potential magnitude and direction of climate change effects, but it is important to understand their limitations and choose model types best suited to a particular application, or consider combining data from a range of models.

Becky Kerns

"No-regrets" management policies meet immediate needs while benefiting future forests. Above, prescribed fire was used to help this stand develop characteristics of an old-growth ponderosa pine forest.

FOR FURTHER READING

Gaines, W.L.; Peterson, D.W.; Thomas, C.A.; Harrod, R.J. 2012. Adaptations to climate change: Colville and Okanogan National Forests. Gen. Tech. Rep. PNW-GTR-862. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 34 p. http://www.treesearch.fs.fed.us/pubs/42153.

Kerns, B.K.; Peterson, D.W. 2014. An overview of vegetation models for climate change impacts. USDA Forest Service, Climate Change Resource Center. http://www.fs.usda.gov/ccrc/topics/overview-vegetation-models.

Littell, J. S.; McKenzie, D.; Kerns, B.K. et al. 2011. Managing uncertainty in climate-driven ecological models to inform adaptation to climate change. Ecosphere. 2(9): 102. http://www.treesearch.fs.fed.us/pubs/39230.

Peterson, D.W.; Kerns, B.K; Dodson, K. 2014. Climate change effects on vegetation in the Pacific Northwest: a review and synthesis of the scientific literature and simulation model projections and practical adaptation approaches. Gen. Tech. Rep. PNW-GTR-900. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 183 p. http://www.treesearch.fs.fed.us/pubs/46520.

Ryan, M.G.; Vose, J.M.; Ayres, M.P., et al. 2012. Effects of climatic variability and change. In: Vose, J.M.; Peterson, D. L.; Patel-Weynand, T., eds. Effects of climatic variability and change on forest ecosystems: a comprehensive science synthesis for the U.S. forest sector. Gen. Tech. Rep. PNW-GTR-870. Portland, OR: USDA Forest Service, Pacific Northwest Research Station: 7–95. Chapter 2. http://www.treesearch.fs.fed.us/pubs/42610.

WRITER'S PROFILE

Marie Oliver specializes in science writing and developmental editing. She can be reached through her website at http://claritywriting.com.

Science

FINDINGS

U.S. Department of Agriculture
Pacific Northwest Research Station
1220 SW Third Avenue
P.O. Box 3890
Portland, OR 97208-3890

SCIENTIST PROFILES

DAVID W. PETERSON is a research forester whose research focuses on fire ecology, forest ecology, restoration ecology, and climate change. His recent studies include work toward improving our understanding of how forest and rangeland vegetation respond to wildfire; how trees killed by wildfire decay and contribute to wildlife habitat, coarse woody debris, and fuels; and how postfire management treatments can best be used to reduce threats and promote long-term ecosystem recovery. He is evaluating the effectiveness of common forest restoration treatments for increasing resilience to fire and climatic variability and promoting biodiversity in fire-prone forest and savanna ecosystems.

Peterson can be reached at:

USDA Forest Service
Pacific Northwest Research Station
1133 N. Western Avenue
Wenatchee, WA 98801

Phone: (509) 664-1727
Email: davepeterson@fs.fed.us

BECKY KERNS is a research ecologist with the Pacific Northwest Research Station in Corvallis, Oregon. She earned a B.S. in geology from University of California, Santa Barbara, and an M.S. in quaternary science and Ph.D. in forest ecosystem science from Northern Arizona University. Her research efforts, which she conducts at multiple biological, spatial, and temporal scales using empirical, experimental, and landscape modeling approaches, increase understanding of how natural and human-caused disturbances and their interactions affect structure vegetation and plant communities.

Kerns can be reached at:

USDA Forest Service
Pacific Northwest Research Station
3200 SW Jefferson Way
Corvallis, OR 97331

Phone: (541) 750-7497
E-mail: bkerns@fs.fed.us

COLLABORATORS

Erich K. Dodson, Oregon State University

Jim Alegria and Louisa Evers, USDI Bureau of Land Management, Oregon/Washington State Office

Becky Gravenmier, USDA Forest Service, Pacific Northwest Region and PNW Research Station